

COMMUTATOR AND ELECTRIC ROTARY DEVICE HAVING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to a commutator and an electric rotary device, e.g., a motor, an electric generator, having the commutator.

A conventional commutator of an electric rotary device, e.g., a motor, an electric generator, is shown in Fig. 5. Commutating piece 12 of the commutator 10 are made of a copper alloy, and they are held on a core 14, which is made of, for example, phenolic resin.

The commutating pieces 12 of a micro motor are often made of a clad material, which is made by adhering two metals, e.g., a copper alloy and a gold-silver alloy.

Another conventional commutator is shown in Fig. 6. In the commutator 10, sliding members 16 are respectively fixed on outer faces of commutating pieces 12, which are made of a copper alloy, and they are held by a plastic core 14. Each of the sliding members 16 is manufactured by the steps of: mixing graphite with a binder, e.g., pitch, plastic powders; molding the mixture with applying pressure; and baking the molded body.

In the conventional commutator 10 having metallic commutating pieces 12 on which a brush slides, oxide films are formed on sliding faces of the commutating pieces 12, on which the brush slides, by oxygen in the air. Since the oxide films is an insulating material, an electric current passes between the brush and the commutating pieces with breaking the oxide films.

Micro projections and cavities are formed in surfaces of the commutating pieces 12, so the brush point-contacts the commutating pieces 12. Namely, contact area between the both is very small. Therefore,

electric resistance between the brush and the commutating pieces 12 are increased, the brush and the commutating pieces 12 are overheated due to small contact area therebetween, and adhesive wear, which is caused by adhering the brush to the commutating pieces 12 and peeling the adhered parts, occurs in the brush and the commutating pieces 12.

In the case of highly overheating the brush and the commutating pieces or generating arc therebetween, the both members are worn by metal transfer, dispersion of a melted metal.

In another case, abrasive wear, which is caused by forming hard substances, e.g., oxides, on one or both of sliding faces of the brush and the commutator and grinding soft parts with the hard substances, occurs when the metal transfer is progressed. Further, metal powders formed by the hard substances accelerate the abrasive wear.

If the adhesive wear or the abrasive wear is highly progressed, a span of life of a commutating mechanism, which includes the brush and the commutator, is much shortened. However, the oxide films formed on the surfaces of the commutating pieces can be broken by the wear, so that an electric current can pass between the brush and the commutating pieces. Therefore, a little wear of the commutating piece is required for operating the electric rotary device.

In the case of the micro motor, current intensity passing through the motor is so small that enough energy for breaking oxide films cannot be gained. Thus, expensive gold is included in sliding faces of a commutator, on which a brush slides, so as not form oxide films thereon.

In the commutator 10 shown in Fig. 6, the sliding members 16 include graphite so as to solve the problem of forming oxide films. However, crystals of graphite are unstable, so oxidization wear occurs in the sliding faces of the sliding members 16 when graphite is heated at 400°C or higher in the air. By the oxidization wear, graphite will be

consumed as CO or CO₂. Therefore, it is improper to use the commutator 10 in the air.

In the case of electric rotary devices using the conventional metallic commutating pieces 12, it is difficult to gain enough sliding characteristics.

On the other hand, in the case of electric rotary devices using the conventional sliding members 16 including graphite, graphite gives enough sliding characteristics.

However, graphite employed in the conventional commutators has a layered crystal structure. Electric conductivity in the direction along faces of crystal layers is highly greater than that in the direction perpendicular to the faces of the crystal layers. By the anisotropy, contact resistance between graphites and between graphite and metal highly vary according to contact directions therebetween. For example, in Fig. 7, an electric current having enough intensity flows in the direction along faces of the graphite 18; the current passes along an arrow. Therefore, efficient must be low. Note that, symbols 17 stand for copper powders, and a symbol 19 stands for a brush.

Further, many projected parts and voids exist in the commutator, so area of contacting the brush 19 must be small; the sliding characteristics of the commutator must be bad in spite of including graphite. By the bad sliding characteristics, the exhaustion (the abrasive wear, the arc wear or the oxidization wear) is apt to be occurred, so that the span of life of the commutator must be short.

SUMMARY OF THE INVENTION

The present invention has been invented so as to solve the problems of the conventional commutators.

An object of the present invention is to provide a commutator

capable of reducing contact resistance between a brush and the commutator, improving efficiency of an electric rotary device and restricting exhaustion of the commutator.

Another object of the present invention is to provide an electric rotary device having said commutator.

To achieve the objects the present invention has following structures.

The commutator of the present invention comprises:

a plurality of commutating pieces having outer faces; and

a plurality of sliding members being fixed on the outer faces of the commutating pieces, the sliding members including carbon nano fibers or carbon nano tubes whose outermost layers have electric conductivity.

Another commutator comprises:

a plurality of commutating pieces having outer faces; and

a plurality of combined sliding sections being fixed on the outerface of the commutating pieces, each of the combined sliding section including a first sliding member and a second sliding member,

wherein the first sliding members include carbon nano fibers whose outermost layers have electric conductivity, and

the second sliding members include no carbon nano fibers, the second sliding members are respectively integrated with the first sliding members, the second sliding members are fixed on the outer faces of the commutating pieces.

In the commutator, the combined sliding sections may further include third sliding members, which include no carbon nano fibers or carbon nano tubes and which are

Further, another commutator comprises:

a plurality of commutating pieces including electric conductive parts, which have sliding faces on which a brush slides; and

a plurality of sliding members including an electric conductive metal and carbon nano tubes whose outermost layers have electric conductivity, the sliding members being fixed on the sliding faces of the electric conductive parts.

In the commutators of the present invention, the sliding members may include graphite.

Further, the electric rotary device of the present invention employs one of the commutators of the present invention.

By employing the commutator of the present invention, the carbon nano fibers or carbon nano tubes reduce the contact resistance between the brush and the commutator; the efficiency of the electric rotary device having the commutator can be improved. Further, exhaustion of the commutator can be restricted, so that a span of life of the commutator can be longer.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described by way of examples and with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a commutator of a first embodiment of the present invention;

Fig. 2 is a perspective view of a commutator of a second embodiment;

Fig. 3 is a perspective view of a commutator of a third embodiment;

Fig. 4 is an explanation view of a section of a sliding member;

Fig. 5 is a perspective view of the conventional commutator;

Fig. 6 is a perspective view of another conventional commutator;

and

Fig. 7 is an explanation view of a section of the conventional sliding member.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

In the following embodiments, known carbon nano fibers and carbon nano tubes are employed as carbon fibers.

Sliding members of a commutator, on which a brush slides, includes carbon nano fibers or carbon nano tubes. One layer or a plurality of layers of the carbon fibers are used. One end or both ends of each layer may be closed by a fullerene-shaped cup or cups.

Note that, the carbon nano fiber means a carbon nano tube whose length is at least 100 times greater than a diameter.

Diameters of the carbon fibers used in the embodiments are several nanometers (nm) to several hundred nanometers (nm), e.g., 300 nm, at the largest.

If the diameter of the carbon fibers is less than 15 nm, electric conductivity is reduced. In the case of the carbon fibers whose diameter is less than 15 nm, if chiral indexes "n" and "m", which defines chiral vector assigning a spiral direction of a crystal structure, satisfy following formulas F1 or F2, the carbon fibers have electric conductivity.

$$n - m = \text{a multiple of } 3 \quad (\text{F1})$$

$$n = m \quad (\text{F2})$$

On the other hand, in the case of the carbon fibers whose diameter is 15 nm or more, the carbon fibers always have electric conductivity.

In the present invention, the carbon fibers is mixed in a material of sliding members of the commutator. Unlike graphite, the carbon fibers have no anisotropy of electric conductivity. Namely, an electric current

can pass surfaces of the carbon fibers in every direction. The carbon fibers mutually contact or contact other members. Therefore, at least outermost layers of the carbon fibers must have good electric conductivity.

In the present embodiments, as an example, the carbon nano fibers or the carbon nano tubes are added to a material of the sliding members including graphite. For example, the material is mixed with the carbon nano fibers or the carbon nano tubes. The mixture is molded with applying pressure. Finally, the molded body is baked to complete the sliding member. Note that, steps of manufacturing the brush is not limited.

The commutator of a first embodiment is shown in Fig. 1. The commutator 26 is manufactured by the steps of: supplying materials of sliding members into a molding die, in which a material including the carbon nano fibers or the carbon nano tubes are provided on the brush side and in which another material including no carbon nano fibers or carbon nano tubes are provided on the other side; molding the materials with applying pressure; and baking the molded body. With these manufacturing steps, the commutator 26 has first sliding members 20, which include the carbon nano fibers or the carbon nano tubes and which are located on the brush side, and second sliding members 24, which include no carbon nano fibers or carbon nano tubes and which are located on the other side.

Materials constituting the sliding members except the carbon nano fibers or the carbon nano tubes are graphite, metal powders, a binder (pitch or synthetic resin powders), an additive (solid lubricant), etc.. The metal powders, the binder and the additive may be optionally used, and amount of them may be adjusted on the basis of use. Namely, they are not limited.

Amount of the carbon nano fibers or the carbon nano tubes too may be adjusted on the basis of use.

In a second embodiment shown in Fig. 2, a commutator 26 has three kinds of sliding members. Each of first sliding members 20 including carbon nano fibers or carbon nano tubes is sandwiched between a second sliding member 22 and a third sliding member 28, which include no carbon nano fibers or carbon nano tubes. The commutator 26 is manufactured by the steps of: supplying materials of the sliding members into a molding die, in which the material of the first sliding members 20 are sandwiched between the materials of the second and the third sliding members 22 and 28 as described above; molding the materials with applying pressure; and baking the molded body.

At the beginning of using a motor, the commutator 26 insecurely contacts a brush due to positioning errors of the brush and the commutator 26, vibration of the brush, etc.. To solve the problem, the commutator 26 has the third sliding members 28. The third sliding members 28 are abrasable layers, which can be easily abraded, so that the commutator 26 can securely contacts the brush after the abrasion.

In a third embodiment shown in Fig. 3, sliding sections of metallic commutating pieces 24, on which a brush slides, are plated with an electric conductive metal. The plating is dispersal plating, in which carbon nano fibers or carbon nano tubes are mixed with a plating solution, and a plating metal 32 enclosing the carbon nano fibers 31 or the carbon nano tubes 31 precipitates on the commutating pieces 24. By the dispersal plating, sliding films 30 including the carbon nano fibers or the carbon nano tubes is formed on the commutating pieces 30.

As shown in a partial enlarged part of Fig. 3, parts of carbon fibers 31 are held and fixed by the plating metal 32.

The dispersal plating is one of means for fixing the carbon nano

fibers 31 or the carbon nano tubes 31. In another case, carbon nano fibers or carbon nano tubes, which have been floated in a gas, may be fixed to the commutating pieces 24 by thermal spraying. Namely, fixing means is not limited.

The commutator 26 of each embodiment can be employed as a commutator of a known electric rotary device, e.g., motor, electric generator. Explanation of the known electric rotary device will be omitted.

The carbon fibers (the carbon nano fibers or the carbon nano tubes) round one layer of graphite crystal. Therefore, the carbon fibers have one dimensional electric conductivity. Contact resistance (electric resistance) between the carbon fibers, between the carbon fibers and the metal and between the carbon fibers and the graphite can be always stable.

Unlike other materials constituting the brush, the carbon nano fibers or the carbon nano tubes are fine materials, so they can enter gaps between particles of other materials (see Fig. 4). In Fig. 4, a symbol 17 stands for a copper powder, and a symbol 18 stands for graphite. Since the carbon fibers 31 (the carbon nano fibers or the carbon nano tubes) fill the gaps between the brush 19, the copper powders 17 and the graphite 18.

By filling the gaps with the carbon fibers 31, concaves or cavities in a surface of the commutator 26, which are caused by the gaps, are filled with the carbon fibers 31, so that roughness of outer faces (sliding faces) of the sliding members, which contacts the brush, can be improved. Namely, smooth sliding faces can be formed.

Further, the carbon nano fibers or the carbon nano tubes are highly chemically stable, so no oxide films or sulfide films are formed thereon. Namely, removing the oxide films or sulfide films, which is essential for the conventional commutators, is not required.

Crystal structures of carbon nano fibers or carbon nano tubes are more stable than those of graphite and glass carbon, so temperature of beginning oxidization of carbon nano fibers or carbon nano tubes is high. Therefore, carbon nano fibers or carbon nano tubes have enough resistance to exhaustion.

Since the sliding faces or the outer faces of the commutator 26, on which the brush 19 slides, is smooth, frictional resistance between the brush and the commutator 26 can be reduced. Further, a projection or projections formed by the metal transfer can be prevented, so that the abrasive wear can be reduced.

By improving the roughness of the sliding faces of the commutator 26, actual contact area between the brush 19 and the commutator 26 can be broader. Therefore, the resistance between the brush 19 and the commutator 26 can be reduced, and load and an electric current can be well dispersed, so that heat generated in the contact parts can be reduced. By reducing the heat, the adhesive wear occurred between the sliding faces of the brush 19 and the commutator 26 can be reduced.

The carbon nano fibers or the carbon nano tubes have not only high electric conductivity but also high heat conductivity. Further, as described above, the fine carbon nano fibers or the fine carbon nano tubes fill the gaps between particles of the materials constituting the sliding faces of the brush 19 and the commutator 26, so that the actual contact area between the both can be much broader. By the broad contact area, heat generated between the brush 19 and the commutator 26 can be dispersed in the commutating pieces, so that deterioration of the commutator 26 and the oxidization wear caused by overheating the sliding faces can be reduced. Therefore, disorganization of the sliding faces of the brush 19 and the commutator 26 can be prevented.

The carbon nano fibers and the carbon nano tubes have high tensile

strength in the axial directions thereof, further they have enough flexibility. Even if the carbon nano fibers or the carbon nano tubes are projected from the sliding face of the commutator 26 which does not contact the brush, they can be easily bent on the sliding face of the brush by load, which is applied when the brush contacts the commutator. With this action, concentrating load to front ends of the carbon nano fibers or the carbon nano tubes can be prevented. Further, side faces of the carbon nano fibers or the carbon nano tubes contact the brush instead of the front ends thereof, the actual contact area between the brush and the commutator can be broader. Note that, in the conventional motor, front ends of projected materials constituting a commutator contact a brush, so their actual contact area is small, and load constitutes to the front ends thereof.

Further, melting point of carbon nano fibers or carbon nano tubes are high, so the arc wear caused by metal transfer can be prevented.

In the commutator of the present invention, expensive carbon nano fibers or carbon nano tubes are provided to only the outer faces (the sliding faces), on which the brush slides, so total amount of them can be reduced. Namely, manufacturing cost of the commutator can be reduced, and a span of life of the commutator can be made longer.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.